Application Note

Capturing Maximum Power from Weak Sources with API Mode Battery Chargers

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ABSTRACT

For some applications, such as video doorbells, or asset trackers, charging the batteries from a weak source is required to maintain the battery voltage for continuous operation and improved end-user experience. Many battery chargers focus on standard adapters and low-impedance input sources, like USB input or wall adapters. TI's new chargers, the BQ25630 and BQ25640, incorporate a new feature called Alternate Power Input (API) mode, which allows for maximum power extraction from weak sources. API mode allows the converter to more efficiently charge the battery with a high-impedance input, while also maintaining the fast charge capabilities with USB-C detection and legacy BC1.2 D+/D- detection.

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Trademarks

1 Introduction

As the quiescent current of portable devices continues to drop, and customers expect longer runtimes from their battery powered products, the need for lower power charging from readily available energy sources is apparent. Utilizing a small solar panel that can efficiently charge the battery in low-light scenarios can significantly improve the runtime of battery powered devices that are designed to operate in low I_Q mode for extended periods of time.

This application note outlines the process for entering and exiting API mode in a real system to extract the maximum power from a small solar panel, or other high-impedance input sources. Pseudo-code examples, flow charts of API mode transitions, and graphs showing the impact on efficiency in API mode are provided.

2 Detailed Usage of API Mode

For the BQ25630 and BQ25640, API mode allows the input current limit to be adjusted with smaller step size of 2.5mA and in a lower current range of 10mA to 100mA. Normal Input Current Dynamic Power Management (IINDPM) has a step size of 10mA and range of 100mA to 3.2A. The charger monitors the specific conditions in which API mode would be beneficial for the converter operation and set the LOW_PWR_ADP_STAT status bit to indicate to the host that using API mode improves the efficiency of the converter.

Table 2-1. IINDPM Settings by Mode

IINDPM Settings	Maximum	Minimum	Step Size
API mode	100mA	10mA	2.5mA
Normal mode	3200mA	100mA	10mA

2.1 Entry and Exit Sequence

The conditions under which the low-power adapter status bit is set are related to the input and output voltage of the charger, generally this is when VBUS approaches a value close to VBAT, and input power is low. There are other times when LOW_PWR_ADP_STAT is not set which could still be helpful to use API mode. In some applications it may be advantageous to control the input current limit from a weak source, for example the rectified voltage of a doorbell. If too much current is pulled from the door-bell it could ring. Therefore, API mode should be enabled all the time in the door-bell example, even if LOW_PWR_ADP_STAT is not active. When using known weak sources, the smaller steps sizes and lower allowable minimum input current limit in API mode can be utilized to prevent an overload of the input source.

API entry and exit sequence utilizing the LOW_PWR_ADP_STAT bit:

1. Read LOW_PWR_ADP_STAT bit
2. If LOW_PWR_ADP_STAT is 1
3. Then set EN_API to 1 and adjust API_ILIM as needed
4. If LOW_PWR_ADP_STAT is 0
5. Then no action is needed
6. If EN_API is 1, IINDPM_STAT is 1, and API_ILIM is 100mA (max)
7. Then exit API mode by setting EN_API to 0

API mode should be monitored by the host. If the input is dynamic, like a solar panel, the API_ILIM register can be set to the maximum of 100mA and Input Voltage Dynamic Power Management (VINDPM) can be used to extract maximum power. Once the IINDPM status is set, then it is best to exit API mode to extract the highest power.

2.2 Use with Solar

The API mode entry and exit sequence, in combination with a Maximum Power Point Tracking (MPPT) algorithm, similar to the one explained in Solar MPPT with Single Cell Battery Charger, can help the charger extract more power in low light solar applications.

For a further improvement to the MPPT outlined in application note Solar MPPT with Single Cell Battery Charger, the starting point of the VINDPM sweep can be selected as 65% of the solar panel Open Circuit Voltage (OCV). Using a more appropriate staring point for VINDPM allows reduced sweeping time; alternatively, for a simple MPPT algorithm, 80% of OCV can be used to program VINDPM directly, without sweeping VINDPM. The OCV of the solar panel can be measured by setting the charger to HIZ mode and using the VBUS ADC as an estimate for the solar panel's OCV.

3 API Mode Data

Testing Conditions

The test setup and data show the conditions required for the LOW_PWR_ADP_STAT bit to become active, and the difference in efficiency if the API entry and exit sequence is followed.

- VREG = 4.4V
- VINDPM = 4.40V with VINDPM_BAT_TRACK = 1 (default)
- VBUS = 4.8V, 120mA to 25mA current compliance sweep
- VBAT = 4.3V

Note

When the VBUS supply has a current compliance below IINDPM, the charger forces the supply into current compliance. This leads to the input supply voltage dropping until VINDPM is reached, and therefore forcing the charger to stay in VINDPM. In this case VINDPM = VBUS = VBAT + 250mV = 4.55V and IVBUS = the compliance current.

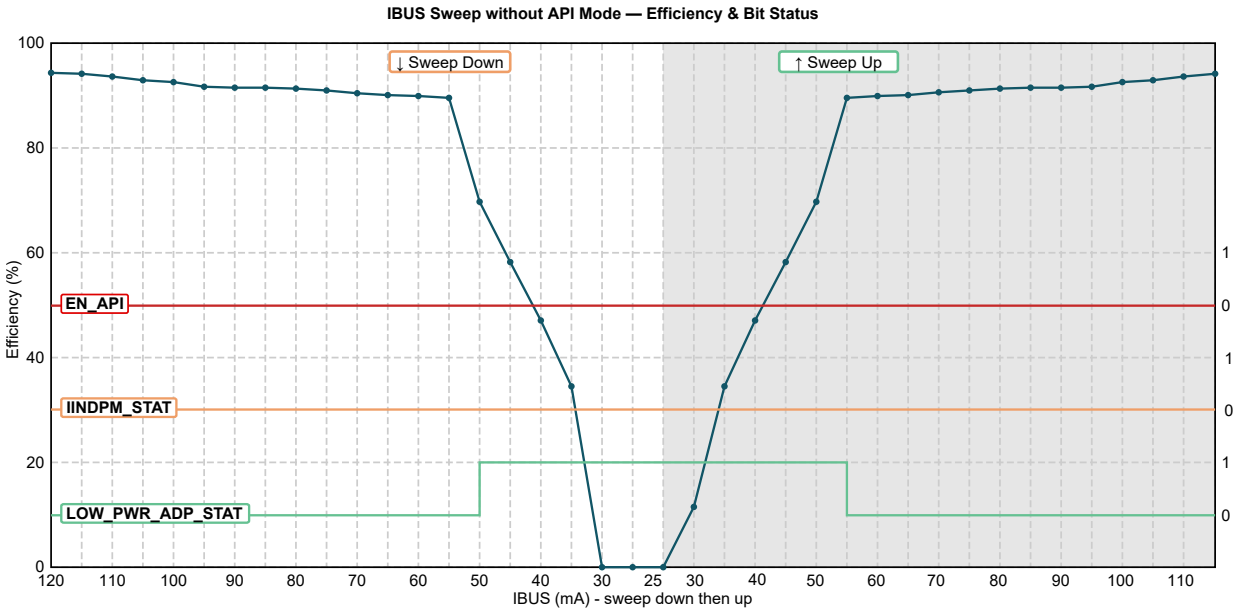

Figure 3-1. Sweeping IVBUS Compliance Without API Mode

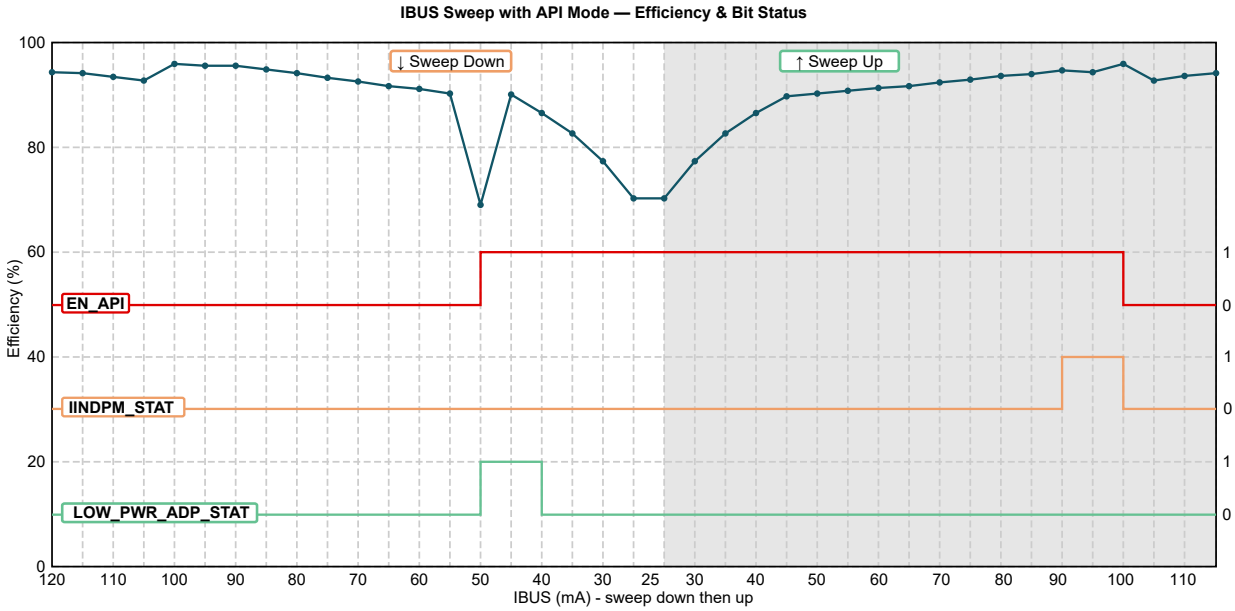

Figure 3-2. Sweeping IVBUS Compliance with API Mode

4 Summary

API mode allows for improved system runtimes by increasing charging efficiency in low input power conditions, when VBUS and VBAT are close to the same voltage. Improved system runtime is accomplished by allowing for continuous low-power charging even when the input source is high-impedance.

As shown in the graphs, efficiency is greatly impacted at low input power operation. Using API mode can allow efficient battery charging, hence maximizing power captured from weak input sources in scenarios where it was not previously possible.

5 References

1. Texas Instruments, *BQ25630 I2 C Controlled Single Cell 5A Buck Charger with USB-C Detection*, datasheet.
2. Texas Instruments, *BQ25640 I2 C Controlled Single Cell 5A Buck Charger with USB-C Detection*, datasheet.

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Last updated 10/2025